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Effect of partially hydrolyzed guar gum on pasting, thermo-mechanical and rheological properties of wheat dough

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ABSTRACT

Partially hydrolyzed guar gum was prepared using enzymatic hydrolysis of native guar gum that can be utilized as soluble fiber source. The effect of partially hydrolyzed guar gum (PHGG) on pasting, thermo-mechanical and rheological properties of wheat flour was investigated using rapid visco-analyzer, Mixolab and Microdoughlab. Wheat flour was replaced with 1–5 g PHGG per 100 g of wheat flour on weight basis. PHGG addition decreased the peak, trough, breakdown, setback and final viscosity of wheat flour. Water absorption and amylase activity of wheat dough were increased whereas starch gelatinization and protein weakening of wheat dough were reduced as a result of PHGG addition to wheat flour. PHGG addition also increased the peak dough height, arrival time, dough development time, dough stability and peak energy of wheat dough system. However, dough softening was decreased after PHGG addition to wheat flour dough. Overall, it can be assumed that PHGG has influenced the properties of wheat flour dough system by decreasing the RVA viscosities and increasing the water absorption and starch gelatinization of wheat dough system.

1. Introduction

Guar galactomannan is obtained from seed of guar plant i.e. *Cyamopsis tetragonolobus*. Currently, guar gum is commercially utilized as stabilizer and thickener in various products such as sauces, soups, dairy products and baked food products [1]. High molecular weight of guar gum (0.1–2.8 million Da) is responsible for its high viscosity. Guar galactomannan molecule consists of linear backbone chain of β-1, 4-linked mannose units with α-1, 6-linked galactose units (2:1) as side chain [2]. Recently, modification of guar gum is in practice due to its various applications. Partially hydrolysis of guar gum can be carried out using ultrasonication, free radical degradation, enzymatic hydrolysis, acid hydrolysis, irradiation and microwave techniques [3–9]. Enzymatic depolymerization of guar gum for its food applications as dietary fiber, is preferred using enzymes such as *endo*-β-D-mannanase [10], pectinase [8] & cellulase [11]. Partially hydrolyzed guar gum (PHGG) is low in viscosity [12] and molecular weight and is a rich source (about 80%) of dietary fiber [13]. PHGG is reported as a good source of water soluble dietary fiber with physiological benefits like increase in defecating frequency and reduction in serum cholesterol, free fatty acid and glucose concentration [14,15].

In the present study, partially hydrolyzed guar gum was prepared via enzymatic hydrolysis using cellulase. Partially hydrolyzed guar gum thus obtained was added to wheat flour suspension and wheat dough to study the effect of soluble fiber addition on pasting, thermo-mechanical & rheological properties which would be helpful in understanding the interaction between the wheat flour constituents and soluble fiber for the development of soluble fiber fortified bakery products.

2. Materials and methods

2.1. Materials

In present study, commercial food grade guar gum sample was obtained from Hindustan Gums & Chemicals Ltd., (Bhiwani) India. Guar gum powder was passed through 200 mesh sieve and stored in refrigerator before use. Cellulase (*A. niger*) and citric acid used in the study was obtained from USB Corporation, USA and Loba Chemie, India, respectively. All other chemicals used were from Sigma–Aldrich.

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2.2. Proximate analysis

Moisture content, ash content, protein content, fat content, total dietary fiber, soluble dietary fiber, insoluble dietary fiber content was determined using AOAC official methods [16].

2.3. Enzymatic hydrolysis of guar gum

Guar gum was partially hydrolyzed by cellulase (*A. niger*) at concentration 0.19 mg/g, pH 5.6, temperature 50 °C and time 4 h [11]. In enzymatic hydrolysis, required pH of distilled water was maintained by addition of citric acid and then cellulase was added at selected concentration. Enzyme addition was followed by guar gum powder addition which was sprinkled in vortex of distilled water using laboratory stirrer at a speed of 800 rpm. Controlled conditions for enzymatic hydrolysis were maintained using BOD shaking Incubator (100 rpm). Low viscosity partially hydrolyzed guar gum solution was obtained after enzymatic hydrolysis. Enzymatic hydrolysis was followed by pH neutralization, sterilization for enzyme inactivation and then filtration and lyophilisation was carried out to obtain partially hydrolyzed guar gum (PHGG) powder which was subjected to further analysis.

2.4. Molecular weight estimation

Viscosity average molecular weight (Mv) of guar gum and partially hydrolyzed guar gum was determined using intrinsic viscosity in Mark-Houwink's equation, $[\eta] = k\ Mv\alpha$ with $\alpha = 0.732$ and $k = 3.8 \times 10^{-4}$ [17]. Molecular weight of monomer unit of guar gum & partially hydrolyzed guar gum used was 270 as reported in literature [18]. Relative viscosity (η_r) was measured by Ostwald's capillary glass viscometer. The relative viscosity value was used in determining specific viscosity ($\eta_{sp} = \eta_r - 1$) from which reduced viscosity $\eta_{red} = \eta_{sp}/C$ was determined. Intrinsic viscosity $[\eta]$ is generally determined by estimating reduced viscosity at different concentrations in dilute solution and extrapolating to zero concentration i.e. C = 0 [7].

2.5. Viscosity analysis

Viscosity of guar gum and partially hydrolyzed guar gum were determined using Brookfield viscometer. 1% (w/v) aqueous solution of guar gum and partially hydrolyzed guar gum was prepared and left overnight for maximum hydration. After hydration, viscosity of guar gum (spindle no. 4) and partially hydrolyzed guar gum. Viscosity of guar gum was measured at 5–100 rpm with shear rates 2.6–52.1 s^{-1}. Whereas, viscosity of partially hydrolyzed guar gum was measured at 20–100 rpm with shear rates 2.6–13.2 s^{-1}. Shear rates were calculated by Mitschka's equations [19].

2.6. Pasting characteristics of wheat flour

The changes in the pasting characteristics of the wheat flour were determined by Rapid Visco Analyzer- TecMaster (Perten Instruments) according to the AACC approved method 76–21 [20]. Partially hydrolyzed guar gum was added to the wheat flour at 1–5% level (w/w), respectively. The different parameters determined by the RVA were peak viscosity, breakdown, trough, setback, final viscosity, pasting temperature (°C) and peak time (min). All the parameters were expressed in cPs.

2.7. Mixolab characteristics of wheat dough

Mixolab is an important instrument used for analysis of thermomechanical properties of wheat dough. In the present study, Chopin + protocol were used for analysis of PHGG supplementation on wheat dough using Mixolab (Chopin, France), which allows mixing of dough under controlled temperature and also a temperature ramp upto 90 °C followed by cooling. It measures in real time the torque (Nm) produced by the dough between the two kneading blades and thus allows the thermo-mechanical behavior of dough. For the assays, 50 g of wheat flour were placed into the Mixolab bowl and mixed with PHGG from 1 to 5% (w/w) flour replacement. Water required for optimum consistency (1.1 Nm) was then added. The parameters obtained from Mixolab curve were water absorption (%), protein weakening (Nm), starch gelatinization (Nm), amylase activity (Nm) and starch gelling (Nm). Percent water absorption represents the percent water required for the dough to produce a torque of 1.1 Nm. Protein weakening or mechanical weakening (Nm) is the torque difference between the maximum torque at 30 °C and the torque at the end of the holding time at 30 °C. Starch gelatinization or peak torque (Nm) represents the maximum torque produced during heating of wheat dough. Amylase activity or cooking stability is the ratio of torque after holding time at 90 °C and the maximum value of torque during heating period. Starch gelling or setback (Nm) is the difference between the torque produced after cooling at 50 °C and the torque after the heating period.

2.8. Microdoughlab characteristics of wheat dough

Microdoughlab was used to study dough mixing characteristics of the wheat flour. The wheat flour was supplemented with partially hydrolyzed guar gum (PHGG) at 1, 2, 3, 4 & 5 g/100 g replacement levels. The selected concentration of PHGG was added to the wheat flour and then the flour was transferred to the mixing bowl of Microdoughlab. In Microdoughlab, firstly the dry mixing of the flour was carried out and then water addition was done. The amount of water to be added in the flour was estimated by the instrument to reach the 500 FU line in Microdoughlab chart [21]. The mixing of the dough continued for 12 min for control and flour samples fortified with partially hydrolyzed guar gum. The mixing parameters determined by the Microdoughlab were peak dough height (FU), arrival time (min), dough development time (min), dough stability (min), dough softening (FU) and peak energy (Wh/kg), respectively.

3. Results and discussion

3.1. Proximate analysis

Guar gum solution obtained after enzymatic hydrolysis was subjected to filtration and freeze drying to obtain powdered partially hydrolyzed guar gum sample. The powder sample of PHGG thus obtained was subjected to further analysis. Moisture, protein, ash and fat content, total dietary fiber, insoluble dietary fiber and soluble dietary fiber of guar gum and partially hydrolyzed guar gum are summarized in Table 1. Results showed that the partial hydrolysis of guar gum led to decrease in moisture, protein and molecular weight. However, an increase in fat and ash content was observed. Decrease in moisture content of PHGG as compared to native guar gum may be due to the freeze drying of PHGG. Protein content is shown to decrease significantly from 4.32% in guar gum to 1.95% in PHGG. This may be due to the filtration of partially hydrolyzed guar gum solution after enzymatic hydrolysis as proteins are insoluble material and are filtered out from PHGG solution. Significant increase in ash content from 0.69% in guar gum to 2.56% in PHGG was observed. This increase in ash content may be due to the neutralization step carried out after enzymatic hydrolysis to neutralize the citric acid which was added to maintain the pH of the solution